

OLIGOCENE-MIOCENE SEDIMENTS OF RIVERSLEIGH: THE POTENTIAL SIGNIFICANCE OF TOPOGRAPHY

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Although faunal assemblages provide the best indication of relative ages and environments of deposition in Tertiary and Quaternary sediments of the Riversleigh region, geological evidence provides additional significant information about the prehistory of the area. Data presented herein on topographic heights of sites in areas of horizontally-bedded sediments lead to an hypothesis of cyclical sedimentation. At least 3 cycles of Oligocene-Miocene sedimentation consist of 4 stages: 1) uplift and/or lowering of the water table; 2) erosion and development of a karst landscape; 3) subsidence and/or raising of the water table, and 4) sediment accumulation within the karst terrain and in surrounding shallow basins

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This paper uses data from Archer et al. (1989, 1994) and Megirian (1992), palaeontology and preliminary mapping using photogrammetric base maps at 1:2,000, 1:15,000 and 1:20,000 to interpret stratigraphy and palaeogeography of Oligocene-Miocene sediments at Riversleigh. I focus on Oligocene-Miocene sediments on D Site and Gag Plateaus dated primarily through biostratigraphically dated deposits in South Australia (Woodburne et al., 1994).

Archer et al. (1989) and Megirian (1992) focussed on D Site and Gag Plateaus, particularly Godthelp's Hill and Hal's Hill areas and the northern Gag Plateau. I concentrate herein on the northern D Site Plateau and the southern Gag Plateau. I also build on Archer et al.'s (1989) observation on the Gag Plateau that it is possible to correlate widely separated exposures of flat-lying sediments. In areas where the sediments are faulted or areas on the margins of microbasins where the beds are dipping, correlation is limited.

All sites have been plotted onto base maps lodged with the Vertebrate Palaeontology Laboratory, University of New South Wales, Queensland Museum and the Queensland National Parks and Wildlife Service. I provide new information on relative topographic heights which contributes to geological understanding of the region.

I consider geographic sections of each plateau and look at the geology of each section (Fig. 1) noting the range of sediment types, presumed age of the sediments based on palaeontological evidence and, where appropriate, topographic heights.

The other area considered is the 'Mesas', isolated erosional remnants of Tertiary sediment E

of the Riversleigh/Lawn Hill road. A number of these sites appear similar in lithology and stratigraphy to sites in the northern section of the D Site Plateau.

I recognise 3 sedimentary sequences (Verdon Creek, Godthelp's Hill and Gag Plateau). The Verdon Creek sequence is best represented in the northern section of D Site Plateau and consists of mainly System A sites (Archer et al., 1989). The Godthelp's Hill sequence occurs in the central section of D Site Plateau with System B sites. The Gag Plateau sequence is best represented in the northern section of Gag Plateau and contains mainly System C sites but may also include System A sites. Recent fieldwork has indicated a lack of uniformity and continuity of the basal sediments in the northern section of Gag Plateau.

D SITE PLATEAU

The northern section includes Neville's Garden/Burnt Ollering area and the major gully system to the south of this area with sites such as Quantum Leap, Gillespie's Gully and MIM. It also includes sites on the eastern edge of the plateau (LSO and Dirk's Towers) as well as the sites on the western edge (BIB). The southern boundary is at or about Syp's Siberia Site to the north of Godthelp's Hill.

The central section includes Godthelp's Hill, Hal's Hill and other sites in the valley to the south east of these hills including White Hunter, ABRS, Sticky Beak and Wayne's Wok.

The southern section includes sites south of Hal's Hill commencing with the Biggles Flies Again Site, SM and TOTE Sites and Bone Reef, Jeanette's Amphitheatre and Chinatown Sites.

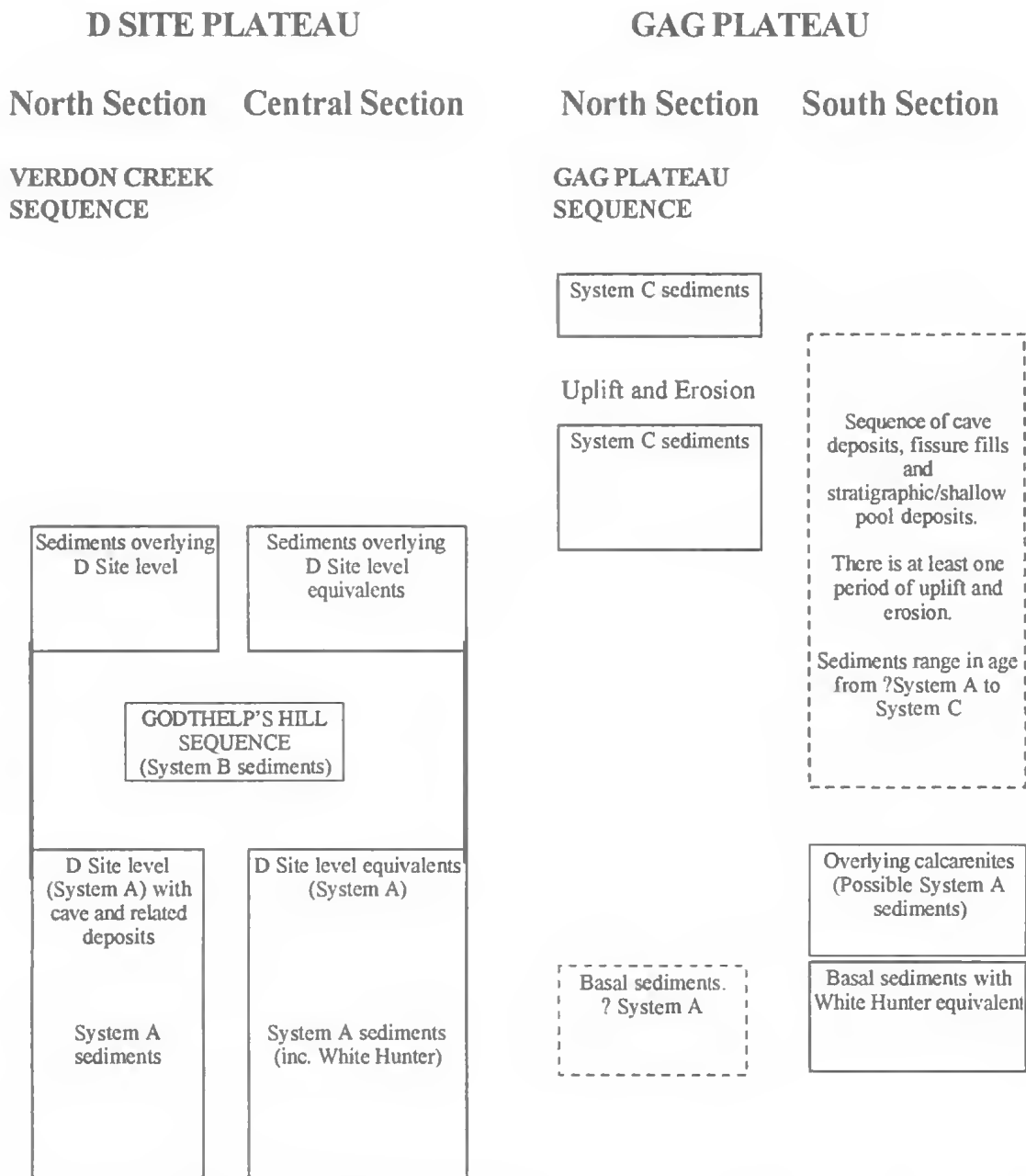


FIG. 1. Generalised Riversleigh stratigraphy based on geological observations, biocorrelations and topographic heights.

NORTHERN SECTION (VERDON CREEK SEQUENCE). This sequence is best seen in the area of Bitesantennary, Burnt Offering and Neville's Garden Sites where it consists of a basal conglomerate, overlain by arenites and calcarenites, up to 20m thick. A 3m homogeneous lime-

stone, the D Site Limestone, overlies these sediments. Cutting into and lying on the D Site Limestone are a series of cave deposits and possibly related tufa deposits. A further series of calcarenites are the highest units of this sequence.

The basal conglomerate consist of a series of

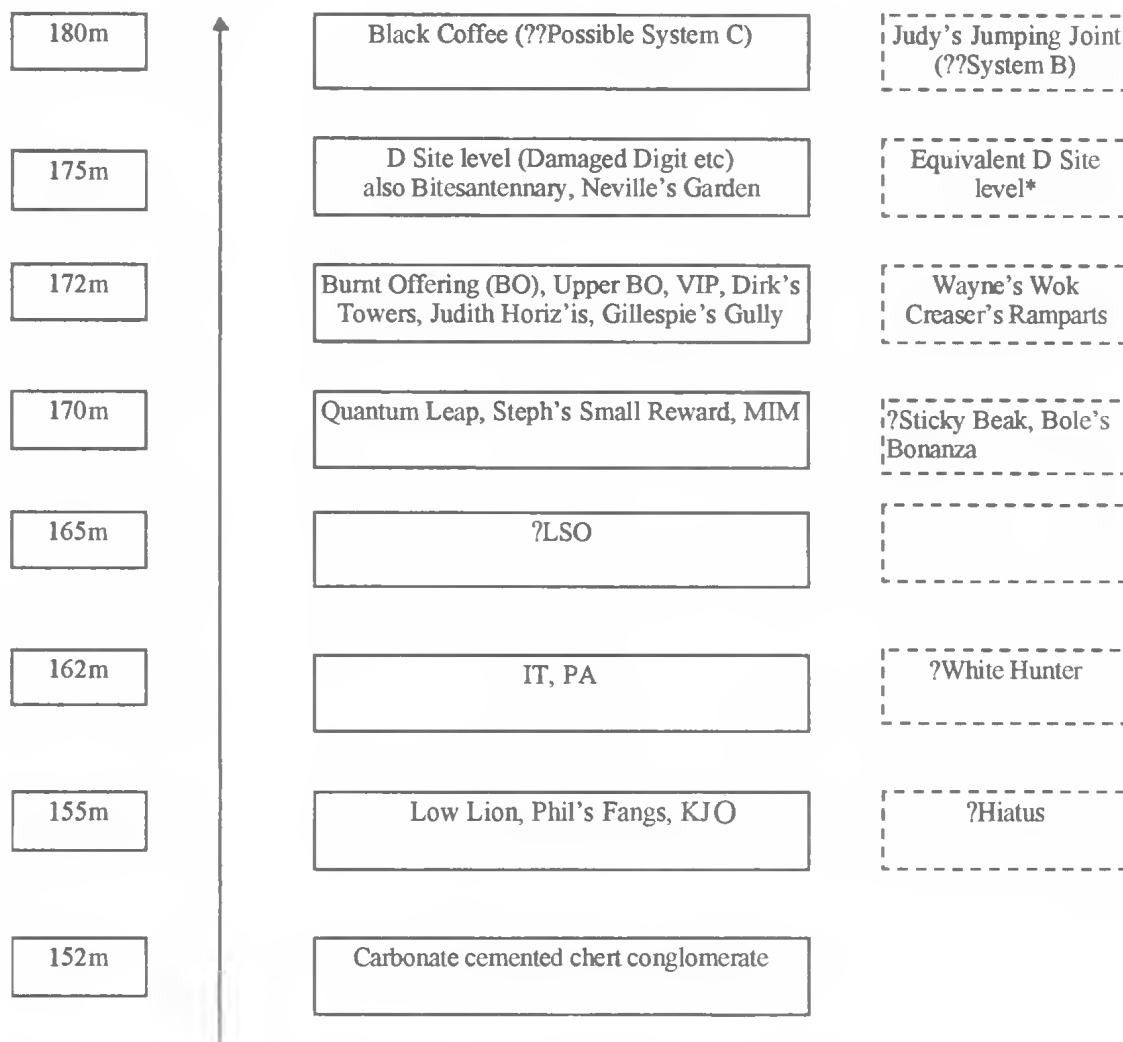


FIG. 2. Verdon Creek Sequence, System A with possible Systems B and C, 'type' section in northern section of D Site Plateau. Heights are in metres above sea level. Dashed boxes indicate relative positions of sites from the Hal's Hill area in the central section.

massive or normally graded, matrix-supported breccias and conglomerates and clast-supported cobble and pebble conglomerates (Megirian, 1992). Archer et al. (1989) questioned whether this conglomerate is contemporaneous throughout the region, suggesting that it could represent different, non-contemporaneous cycles of local weathering. The thickness of conglomerate varies considerably throughout the D Site Plateau.

There are several fossiliferous levels in the overlying arenites and calcarenites (Fig. 2) dominated by turtles, crocodiles, large birds and rare marsupials (usually diprotodontids).

The lowest level at the northern end of this section includes Low Lion and Phil's Fang Sites. A distinctive 25m wide fossiliferous horizon at the Low Lion level is at the same level as KJO Site. The level is dominated by large bone fragments similar in colour and preservation to fossils from Low Lion Site.

Above this level at the northern extremity of the Plateau are the IT and PA Sites which yielded jaw fragments of *Yalkaparidon*. These two adjacent sites, which contain small terrestrial assemblages, are the only ones known from the lower part of the sequence in this area. Although there

are other fossiliferous assemblages at about this level, they tend to consist of well-worn fragments of aquatic vertebrates.

The next fossiliferous level includes LSO Site. Above this are sites in the major gully in the northern part of this section including Quantum Leap, MIM and Steph's Small Reward Sites. Cooke (1997) considered the Quantum Leap Site kangaroos to be most similar to others from System A or B assemblages; its stratigraphic position and sedimentology suggest that it is a System A assemblage.

Above these sites but below the D Site Limestone level, is a higher more widespread fossiliferous level which includes Burnt Offering, Upper Burnt Offering, VIP, Judith Horizontalis, Punky Brewster, Gillespie's Gully and Dirk's Towers Sites. These appear to be stratigraphically controlled and do not represent a later incised deposit. While they are at the same topographic level and appear to be horizontally bedded, they may be of different ages.

Black (1997a) suggested that Burnt Offering is a System A site. Cooke (1997) suggested it might be a System B site; the macropodid fauna indicates that it could be either System A or B. Black (1997a) considered that Upper Burnt Offering is a System B site but *Neohelos* n. sp. 1 is only found in System A deposits. Black (1997a) considered VIP to be a System A site on the basis of a plesiomorphic zygomaturine. As yet, there is insufficient data from the Judith Horizontalis, Punky Brewster and Gillespie's Gully Sites to allocate these and no clear evidence from Dirk's Towers Site as to whether it is System A or B.

D Site Limestone is a distinctive marker bed that outcrops over much of the D Site Plateau and is characterised by a fossil assemblage of mainly large vertebrates dominated by mekosuchine crocodiles, dromornithids and diprotodontoids. However, the stratigraphy of D Site (Tedford, 1967) and of the ridge to the north of D Site, are less readily interpreted because of extensive scree slopes.

Archer et al. (1989) equated the D Site Limestone and its fossil assemblages with their System A. However, given further research since the mid 1980s and recognition of several fossiliferous levels well below this marker bed, it is recommended here that System A be expanded in concept to include all of the lower sediments of the Verdon Creek sequence.

A complex series of eave and possibly also tufa deposits have been etched into the D Site Limestone. This suggests a period of uplift or lowering

of the water table following deposition of the D Site Limestone, followed by karst weathering of the limestone to form eaves and other sediment/fossil traps, and then infilling of these microbasins. The best known cave sites are Microsite and Bitesantennary Site with the best example of a tufa deposit being Neville's Garden Site with sediment and fossils accumulating at and beyond the entrance to a cave. However, Neville's Garden Site may represent a stratigraphically controlled site which can be correlated with Dirk's Towers or Judith Horizontalis Sites from this section or possibly Wayne's Wok and Creaser's Ramparts Sites from the central section of this Plateau. Black (1997) and Cooke (1997) assign this site to System B on its diprotodontoids and macropodoids respectively.

A thin series of calcarenites overlies the D Site Limestone and the cave and tufa deposits. However, fossils from these sediments are not common and only one site in this section, Black Coffee Site (above Gillespie's Gully), has been sampled. Its faunal assemblage has yet to be analysed in detail.

Topographically, the base of this sequence at the northern end of the Plateau is at 152m with the lowest fossiliferous level at about 155m (Low Lion and KJO Sites). The base of the D Site Limestone is at 175m. The highest point on the D Site Plateau is at 202.7 m. Above Neville's Garden Site, the highest point is 192m which would give a thickness of at least 40m.

CENTRAL SECTION. The central section contains the discreet, richly-fossiliferous Godthelp's Hill sequence which is separated both stratigraphically and topographically from other sediments in this section which are similar in lithology and stratigraphy to the Verdon Creek sequence. The Godthelp's Hill sequence may be the equivalent of the cave and tufa deposits of the Verdon Creek sequence. The other sediments can probably be equated to the other Verdon Creek sequence sediments.

GODTHELP'S HILL SEQUENCE. Because they are separated, possibly due to faulting (Megirian, 1992), from the main sequence it is not clear whether the tufa deposits on Godthelp's Hill are the equivalent of the cave and related tufa deposits of the Verdon Creek sequence. Although faunal assemblages indicate a similar age, the Godthelp's Hill sediments, which have been regarded as System B (Archer et al., 1989), are regarded as a distinct sequence (Fig. 3). The

GODTHELP'S HILL SEQUENCE

VERDON CREEK SEQUENCE

Highest

View Delightful
Panorama
Ten Bags
Boid
Boid Site East

CAVE DEPOSITS
Bitesantennary
Microsite

CAVE/POOL DEPOSITS
Neville's Garden

All occur at the D Site Level

Mid/High

Helicopter
Mike's Potato Patch

Mid

Upper
CS
Inabeyance
Mike's Menagerie

Mid/Low

RSO
RV
Outasites
Souvenir

Others

G Spot, DDDD, Victor's Vacuum, Paul Willis, Dredge's Ledge

FIG. 3. Godthelp's Hill Sequence, System B with possible System B equivalents from the Verdon Creek Sequence.

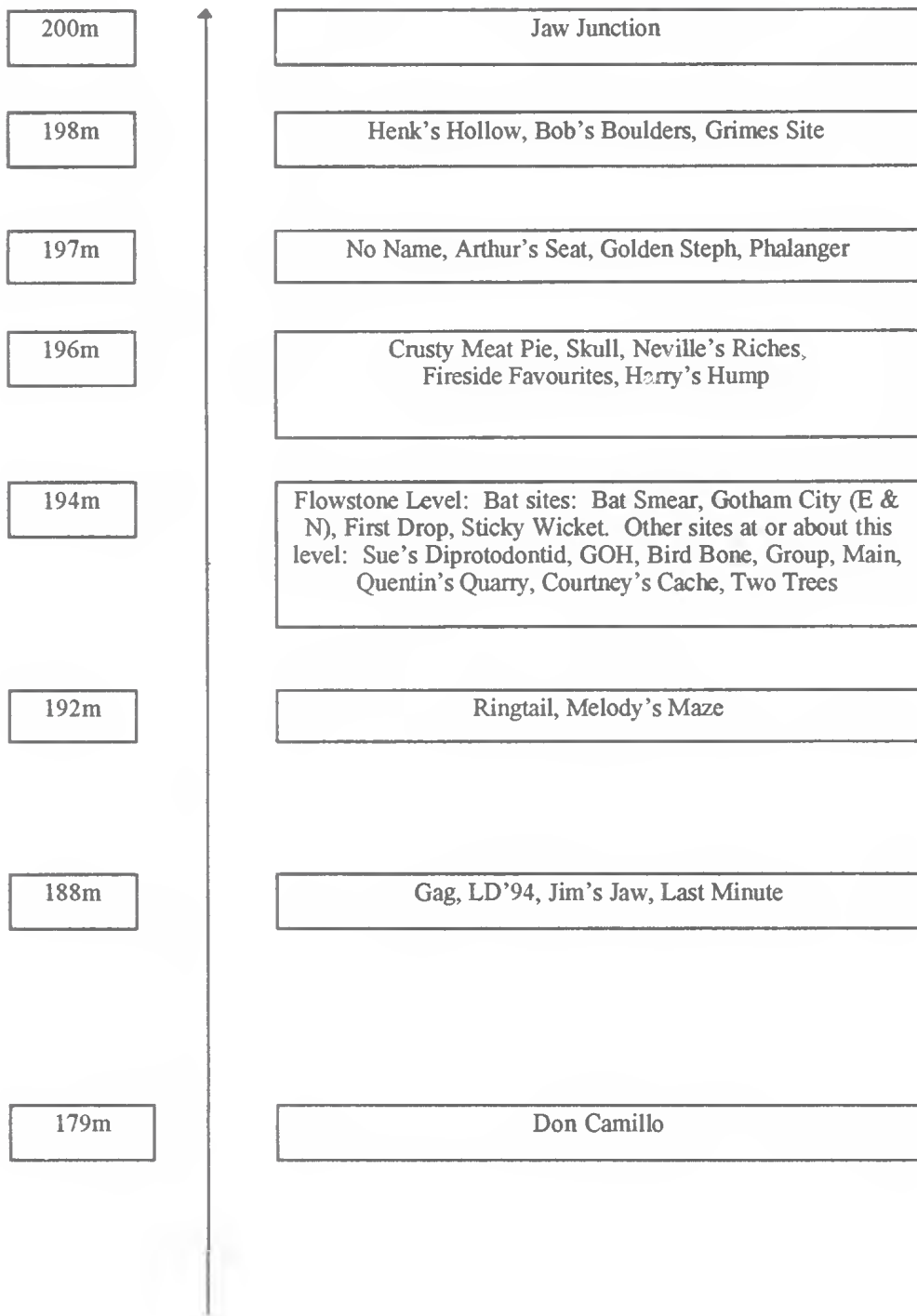


FIG. 4. Gag Plateau Sequence, System C, 'type' section in northern section of Gag Plateau based at Don Camillo Site. Heights are in metres above sea level. Sites to be plotted: Archie's Absence, Archie's Parlour, Bernie's Bedford, Kangaroo Jaw, Lockwood's Link, and Bruty and the Beast.

thickness of the sediments on Godthelp's Hill has been estimated to be 7m (Archer et al., 1989) to 12m (Megirian, 1992). Detailed photogrammetry of the area indicates that the estimate of 12m is more accurate.

OTHER SEDIMENTS IN THIS SECTION.

These sediments are around Hal's Hill to the south of Godthelp's Hill. Hiatus Site, the lowest in this area, is just above Precambrian sediments on the northern side of Hal's Hill. Although there is some doubt about its position because of faulting, it appears to be a base level. Black (1997a) notes that *Silvabestius michaelbirti* from Hiatus South Site is the most plesiomorphic zygomaticine known. Stratigraphic and topographic position and faunal assemblage suggest that White Hunter Site on the south side of Hal's Hill is very low in the sequence. However, its lithology differs from that of Hiatus Site and the basal sediments in the northern section of the Plateau. Black (1997a) indicates that Hiatus South Site belongs to System A. Cooke (1997) considers it a System ?A/B Site because several macropodoid species from White Hunter Site are also found in other undoubted System A and B sediments. However, there are also 5 unique macropodoid species from this site. Myers & Archer (1997) indicate White Hunter Site is the only one at Riversleigh that contains ilariids. Taken together, these suggest that White Hunter either represents a distinct interval of time or, if contemporaneous, a different ecosystem. I suggest that White Hunter Site is a basal System A deposit.

There are no distinctive fossiliferous levels immediately above either Hiatus or White Hunter Sites. The next site up section may be Sticky Beak Site which is a lower level than the D Site Limestone equivalent, approximately at the same level as Boles' Bonanza Site. Black (1997a) suggests that Sticky Beak Site belongs to System A.

The next level up is immediately below the D Site Limestone level equivalent. In this section, Wayne's Wok and Creaser's Ramparts Sites are at this level and may be correlated with Dirk's Towers and Judith Horizontalis Sites from the northern section. Both Black (1997a) and Cooke (1997) consider Wayne's Wok Site to be low in System B. However, this site contains a number of species that are found in Systems A and B. The age of Creaser's Ramparts Site is also unclear and more palaeontological information is needed. Black (pers. comm.) recognised a phascolaretid from this site, that is the most primitive from the Australian Tertiary.

In this section, the only D Site Limestone equivalent site is Neville's Pancake Site (with a plesiomorphic meiolaniid turtle; Gaffney et al., 1992). Fig Tree Site, with the most plesiomorphic zygomaticine *Nimbadoron*; Hand et al., 1993 is stratigraphically below Neville's Pancake Site. Both sites are NE of Hal's Hill.

Above the D Site Limestone level, in the overlying calcarenites, only Judy's Jumping Joint site has been sampled. This site is a localised conglomerate found on the crest of Hal's Hill and belongs to System B. However, because the relationships are not clear, it is not possible to determine at present whether these calcarenites represent System A or B.

SOUTHERN SECTION. There has been relatively limited exploration in this section of the Plateau with preliminary fieldwork indicating a thin series of sediments. Sites such as Bone Reef and Jeanette's Amphitheatre are as yet largely unassessed. They are dominated by large animals more or less of the same kind (but far more abundant) that characterise the D Site Limestone at, for example, Site D. Black (1997a) considers these two sites System A deposits. Immediately below these are fossiliferous sediments. Two other sites collected from this region are Chintown, which produced a System B assemblage, and a possible eave deposit with a rich bat fauna. SM and TOTE Sites, in the northern part of this section, are dominated by large vertebrates.

GAG PLATEAU

The northern section includes the vast range of sites at the northern end of the Plateau including Golden Steph, GOH, LD94 and First Drop. The central section is relatively barren apart from Wang Site and this relative lack of sites is its defining feature. The southern section includes AL90, COA, Dunsinane, Dome, JC, Encore and others. The northern boundary of this rich southern section is at Peter the Pilot Site.

NORTHERN SECTION (GAG PLATEAU SEQUENCE). Based on a composite section starting with Don Camillo Site at the base (near the northern point of this section), up through Gag Site to Jaw Junction Site at the top, together with equivalent sites at the appropriate levels at the northern end of this section, the Gag Plateau sequence was considered (Archer et al., 1989) to consist of fossiliferous basal sediments overlain by calcarenites and a series of tufa and 'deep water

pool' deposits which, in some cases, contain diverse faunal assemblages. However, this sequence contains a complex variety of basal sediments. At Don Camillo site, which was considered the stratigraphic equivalent of the D Site Limestone, significantly different lithologies are present. At the eastern end of this section is a fossiliferous conglomerate and at the western end a vertical sequence of richly fossiliferous sediments. Overlying the Precambrian is a thin sequence of arenaceous sediments overlain by fossiliferous calcarenites which in turn are overlain by (?) weathered lateritic sediments. These are overlain by the 'typical' calcarenites which in some places have rich vertebrate assemblages. However, none of these sediments are apparently continuous across the northern section of the Gag Plateau. Some of these basal sediments may be lateral equivalents of System A sediments in the Verdon Creek sequence.

While the basal sediments vary considerably, there is apparently more uniformity higher in the sequence including the tufa and 'deep water pool' deposits of Archer et al. (1989). The tufa deposits such as Gag, Henk's Hollow and Golden Steph Sites, are dominated by terrestrial faunas. In contrast, the 'deep water pool' deposits, such as Crusty Meat Pie, Quentin's Quarry, Bob's Boulders and Ringtail Sites are dominated by aquatic faunas.

Don Camillo Site is at approximately 179m with the highest point at 201m (Jaw Junction Site), giving a maximum thickness of 22m assuming the beds are horizontal. Gag, Last Minute and LD'94 Sites are all at 188m with the erosional break recognised by Archer et al. (1989) and Megirian (1992) at 194m. The only sites with significant bat accumulations (Gotham City, Sticky Wicket, Bat Smear and First Drop Sites) are found at this level (Fig. 4).

CENTRAL SECTION. Only Wang Site is known from this section, with no clear 'dividing line' between the northern and southern sections. However, sediments in the southern section differ in the type and extent of their lithologies and faunas.

SOUTHERN SECTION. The stratigraphy of this section is complex. Unlike the northern section of the D Site Plateau or the upper northern section of the Gag Plateau, the series and types of sediments in the southern section are apparently not limited in lateral extent, often significantly different in age and do not appear to be horizontally

bedded. This makes it particularly difficult to correlate this section with others (Fig. 5). Palaeontological evidence from this section allows some correlations.

The oldest recognised sediments are at Dunsinane Site (and equivalents) with plant and animal fossils. These sediments are overlain by less fossiliferous calcarenites into which are incised richly fossiliferous cave and fissure fill deposits.

Dunsinane, Sue's Rocky Road, Custard Tart and Bernie's Cooking Pot Sites may represent the oldest from the Gag Plateau, possibly System A, on the basis of correlation of mammals with White Hunter Site (Arena, 1997; Cooke, 1997).

Fossils are not common in the overlying calcarenites at Anna's Horribilis, Two Gloves, Anton's Pixie, Arachnid Ridge and Don't Ask Me Sites, all of which have yet to be studied in detail but are probably System A sites. Faunas and lithologies indicate cave deposits at Dome, AL'90, Peter the Pilot, Creaser's Crouch and Angela's Bat Pate Sites. Fissure fill deposits such as COA and Keith's Chocky Block Sites are easily recognisable because of their lithologies. Jim's Carousel and Encore Sites could represent tufa deposits incised into a pre-existing Tertiary limestone.

While the lithologies and environment of deposition of many of these sites are similar, it is clear that they represent a wide range of ages. Black (1997a) suggests that AL'90, Jim's Carousel and Dome Sites may all be System C deposits. Black (1997a) suggests that COA Site may be a System A site, but Cooke (1997) suggests it is either System A or B. A. Gillespie (pers. comm.) considers it to be System B. Encore Site despite being lithologically very similar to other sites in the area, is early late Miocene, System C (Archer et al., 1994; Black, 1997b).

ENVIRONMENTS OF DEPOSITION AND PALAEOGEOGRAPHY

The Tertiary limestone deposits of the Gregory River area are freshwater fluvio-lacustrine deposits. Archer et al. (1989) recognised a complex series of lacustrine, alluvial, travertine and cave deposits while Megirian (1992) has documented alluvial, tufa and karst facies.

I agree with these views and propose that a cycle of sedimentation/erosion that involves: 1, uplift and/or lowering of the water table; 2, erosion and development of a karst landscape; 3,

Central Section

Wang Site

Southern Section**Cave Deposits**

Peter the Pilot,
Creaser's Crouch (CC)
Upper CC
Nicole's Boulders W
AL'90
Captain Androgen
Jolly Roger
Bernards Belted Belfry
Angela's Bat Pate
Bat Eerk
Anne's Bat Room
Dome (N & S)
Jeanette's Bat Stuff

Fissure fills

COA
Keith's Chocky Block

Stratigraphic/Shallow Pool Deposits

Arachnid Ridge*
Nicole's Boulders
JC Sites
Not JC8
Anna's Horribilis*
Two Gloves*
Encore
Angela's Sinkhole
Don't Ask Me*
Anton's Pixie*

Dunsinane, Custard Tart, Sue's Rocky Road,
Bernie's Cooking Pot
Equivalent to White Hunter Site on D Site
Plateau

FIG. 5. Gag Plateau Sequence, central and southern sections. The age of these sites is unclear (apart perhaps from Dunsinane Site and its equivalents) although there is evidence that there is a range of different ages represented. Deposits marked * appear to represent faunas from the calcarenites which overlie the Dunsinane Site and its equivalents.

subsidence and or raising of the water table; 4, sediment accumulation within the karst terrane and surrounding basins. This 4-stage cycle occurred at least 3 times during Oligo-Miocene time at Riversleigh. Each new cycle may have been initiated by minor tectonic activity that may have been responsible for changes in the hydrogeologic system. Megirian (1992) noted faulting on Godthelp's Hill which may have been responsible for deposition of the basal conglomerates as a debris flow.

Following initial observation by B. Cooke that Tertiary limestone on the mesas not uncommonly rest directly on Precambrian quartzite, M. Archer

demonstrated that there did not appear to be anywhere on either the D Site Plateau or the Gag Plateau where Tertiary sediments directly overlay the Cambrian limestones. In a number of places, however, Tertiary sediments can be found adjacent to Cambrian limestones (e.g. Microsite which is topographically situated between a high of Thornton Limestone to the west and D Site Limestone to the east) which suggests that karst topography of Cambrian limestones may have controlled sedimentation patterns in the Tertiary.

I suggest that the basal arenaceous sediments and the overlying calcarenites were deposited in an alluvial fan/braided stream environment.

Given the outcrop pattern, it is likely that the streams flowed in a northeasterly direction. As Megirian (1992) has noted, fossils are not common in this type of environment. However, in some parts of this environment, possibly in swamp areas or stagnant water away from the forest, assemblages of large aquatic and terrestrial animal fossils accumulated. In other areas freshwater limestone tufa pools developed in or at the edge of the rainforest but these are relatively rare. The level containing rich faunas from sites such as Dirk's Towers, Creaser's Ramparts, Judith Horizontalis and Burnt Offering Sites, is a notable example. These sites are often found in gullies today because they are more easily weathered than the surrounding more resistant sediments. There does not appear to be any breaks in this part of the sequence and it is suggested that this sedimentation continued until (?) tectonic activity or a raised water table led to the empondment of larger lacustrine bodies of water in which accumulated the sediments (e.g., the D Site Limestone) exposed at localities such as D Site. These sediments are fairly uniform in lithology apart from the northeastern corner of the D Site Plateau (near the Lawn Hill road and Verdon Creek) where there is a high percentage of quartz grains suggesting a Precambrian source to the northeast. Large vertebrates, including crocodiles and turtles, are common in this limestone which is considered to represent an open lake or swamp, at some distance from the rainforest. This would explain the scarcity of terrestrial faunas especially when compared to the shallow pool tufa deposits (Archer et al., 1989).

Renewed tectonic uplift and/or a lowering of the water table resulted in renewed development of a karst landscape in the Tertiary as well as Cambrian limestones. This enabled formation of caves and their subsequent filling with fossiliferous deposits (e.g. Microsite and Bitesantennary Site), as well as deposits formed at cave entrances (e.g. Neville's Garden Site where fragments of speleothems (straws) and in situ travertine rills and small stalagmites have been found).

Godthelp's Hill sequence is regarded as a separate unit, which may be equivalent in part to these cave deposits. Lithology of the sediments and the fossils from sites on Godthelp's Hill suggest tufa deposits that accumulated over a period of time.

The uppermost series of calcarenites in the Verdon Creek sequence suggest a return to the alluvial braided stream facies, possibly following erosion of the karst landscape. These sediments

may be the lateral equivalents of the System C sediments at the northern end of the Gag Plateau, or alternatively they may be part of System A. System B faunal assemblage from the conglomerate at Judy's Jumping Joint Site does not enable any definite conclusions to be drawn because the relationship of this Site to the surrounding sediments is unclear.

The basal sediments at the northern end of the Gag Plateau vary from fossiliferous conglomerates to arenaceous sediments and weathered lateritic sediments. These sediments are overlain by calcarenites that suggest an alluvial braided stream facies, and a fossil-rich tufa and deep pool (aquatic) deposits. Like similar deposits in the Verdon Creek sequence, the tufa deposits appear to have accumulated in and around shallow terrestrial pools. There is no clear pattern evident in the distribution of these two types of shallow water tufa and deep water deposits. There is also a significant erosional break in the sequence that can be recognised in the field by flowstone and travertine deposits. Palaeontological evidence also indicates a significant break between the upper and lower parts of the sequence in this area and it may be no coincidence that the only sites in this area which contain significant bat accumulations are at this level. This suggests another cycle of uplift and/or lowering of the water table, cave development, cave fill, and erosion before sedimentation recommenced.

In contrast, there are apparently no similar sequences of shallow water tufa or deep pool deposits at the southern end of the Gag Plateau. Isolated sites such as Jim's Carousel Site, however, may be of this type. It is not clear if the sediments at the northern end are equivalent to the main sequence of sediments at the southern end of the Plateau.

Mammals from Dunsinane and related sites at the southern end of the Plateau, which appear to represent basal sediments, suggest correlation with White Hunter Site, a probable System A assemblage (Arena, 1996, 1997). These sediments are overlain by a series of calcarenites which were probably deposited in an alluvial fan/braided stream environment. Associated with the calcarenites are cave and fissure fill deposits which have been incised into the earlier Tertiary limestones indicating that a karst landscape had already been formed. The age of these cave and fissure fill deposits appears to range considerably with some (e.g., Encore Site) being the youngest Oligo-Miocene sediments in the region.

PALAEOENVIRONMENT

On the basis of the fossil faunas, Archer et al. (1989, 1994) suggested that rainforest covered the region at least during the early to middle Miocene. Archer (pers. comm., 1996) suggests that there is much less faunal evidence for rainforest being ubiquitous during the late Oligocene. Other researchers support this view although there seems to be evidence that this rainforest was unlike any found in Australia today and that the rainforests of New Caledonia or mid-montane Papua New Guinea may be more similar. Boles (1997) and White (1997) suggest that there were some patches of open forest. Megirian (1992) suggested the rainforest was a refugium confined to the proximity of perennial, spring-fed streams. He concluded that the palaeoclimate was relatively dry, perhaps semi-arid, despite the fact that the sediments were considered to be characteristic of humid alluvial fans. Archer et al. (1995) refuted this suggestion on faunal evidence. Creaser (1977) has also showed that although calcilithites, terrigenous clastic rocks in which carbonate fragments dominate, form mainly in alluvial fans in arid/semi-arid and glacial/periglacial environments, they are also forming today on the Huon Terraces in Papua New Guinea where tectonism and climate both appear to influence the accumulation of the calcilithites. The Huon Terraces are in a rainforest environment with 2000-2500mm of rain per annum. The rainfall has a marked peak in December to February, with the nearby mountain ranges forming a rainshadow, and a pronounced dry season at other times of the year. While there are differences between the Huon Terraces and the Gregory River region, it is possible for a species-rich rainforest to exist in an area of tectonic activity and produce the full range of sediments evident in the Gregory River basin. Although there is no evidence for seasonality in the early to middle Miocene sediments of Riversleigh, growth rings in wood fragments (*Nothofagus* sp.) from Dunsinane Site suggest seasonality (Jane O'Brien, pers. comm.) or at least episodic changes in growth rates. Unfortunately, the age and relative stratigraphic position of these fragments is in doubt (Arena, 1997). They could be either late Oligocene or late Miocene, both icehouse intervals (Frakes & Macgowran, 1987) when rainforest is less likely to have characterised the region. The plants of Dunsinane Site may have grown on the edge of a forest clearing, surrounding the Dunsinane body of water.

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